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G95-1260 Fate of Insecticides Used for Termite Control in Soil

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NebGuide

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Fate of Insecticides Used for Termite Control in Soil

This NebGuide provides information on effects of soil and chemical properties affecting behavior of termiticides in soil.

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Termites cause substantial damage to residential and commercial buildings in the United States. It has been estimated that the annual cost for controlling termites and repairing their damage in the United States exceeds $1.7 billion. Subterranean termites, the most destructive of all termites, account for 95 percent of this damage.

Because subterranean termites are soil-inhabiting social insects living in complex colonies, the conventional control method is to establish an insecticide barrier between the termite colony (usually in soil) and wood in a building. Currently, Pest Control Operators (PCOs) who specialize in termite treatments have access to more than 11 insecticides (termiticides) for subsoil application. However, due to differences in soil characteristics, and physical and chemical properties of termiticides, PCOs and the general public often question how the soil and termiticide will interact. How long will the insecticide be effective in the soil? Is the degradation rate the same in different soils? Will the termiticide leach through the soil and contaminate nearby water sources?

It is important to examine some of the soil factors and chemical properties of termiticides that affect the behavior of these compounds to better understand these issues.

Major factors influencing efficacy and persistence of termiticides are:

1. Soil characteristics
   a. soil texture (clay and organic matter contents)
   b. soil pH
   c. soil moisture
   d. soil temperature
   e. soil microorganisms (microbes)

2. Chemical factors
    a. solubility in water
    b. chemical degradation
    c. microbial degradation
    d. photodegradation
    e. volatilization

Soil Characteristics

Soil Texture

Clay and organic matter contents are important characteristics influencing termiticide sorption mechanism. Clay and organic matter in soil can vary from less than 1 percent in sand to well over 50 percent in heavy clay soils. The vertical and horizontal distribution of termiticides is dependent upon the interaction with soil particles through processes called adsorption and desorption.

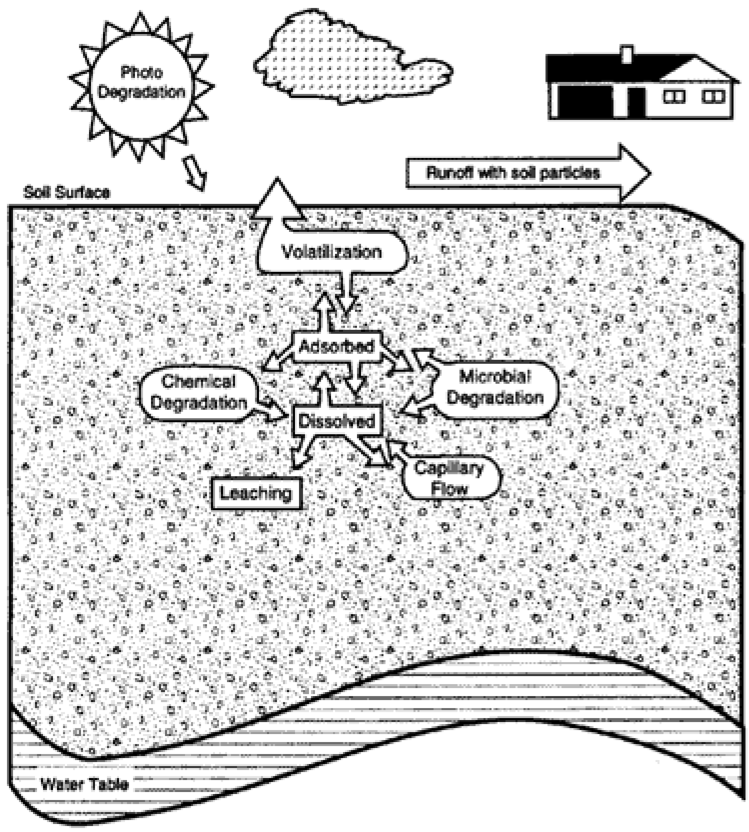

Figure 1. General fate of insecticides used in soil for termite control (modified from F.L. McEwen and G.R. Stephenson, 1979, The Use and significance of Pesticides in the Environment. Wiley InterScience Publisher).

Adsorption is the binding of a termiticide to the surface of soil particles, especially clay and organic matter. Desorption is the release of adsorbed chemicals from a soil particle surface. Depending on many factors in a soil profile, such as moisture, pH, temperature, etc., compounds may adsorb and desorb from soil particle surfaces as they migrate down through the soil. It is also important to consider the clay, sand and silt content of soils because insecticides generally do not migrate as readily in soils with high clay and organic matter contents. The mineral content of soil is also an important factor in determining the persistence of termiticides by either catalyzing decomposition or affecting the adsorption rate. Because groundwater contamination is an extremely important issue to PCOs and the general public, understanding how compounds bind to soil particles is an important part of evaluating whether a termiticide will leach. However, there are no conclusive research data to determine how adsorption/desorption affects termiticide efficacy and application rate in different soils. It is generally assumed that since termites come in contact with soil particles, it may not be necessary to adjust termiticide dilution rates for most soils. Additional research is needed to accurately determine if variable rates are needed.

Soil pH

The soil pH is known to have a major impact on performance of termiticides because it affects how rapidly a compound degrades. The pH is used to describe whether soil is acidic (pH less than 7) or alkaline (pH above 7). Most soils have pH values between 4 and 8. In general, termiticides used today persist longer in acidic soil than in alkaline soil.

Soil temperature and moisture

For the most part, termiticides will remain more efficacious and persistent in soils with low temperatures and low moisture content. Warm soil temperatures and moist conditions can enhance the activity of insecticide-degrading microorganisms, thereby increasing degradation of compounds.

Soil Microorganisms

Microbial degradation is another process in which soil microbes utilize insecticides as substrate (food source) for growth and maintenance. However, little information is available on how microbial degradation of registered termiticides occurs in various soils.

Chemical Characteristics

The second major element affecting termiticide performance involves the chemical characteristics of each insecticide.

Solubility

Solubility of termiticides in water is an important factor affecting their distribution and mobility in soil, but it is not necessarily the best indicator of performance. For example, soluble compounds may have strong affinity to adsorb to soil particles, subsequently limiting their mobility through soil. Ultimately, a combination of factors determines the termiticide mobility in soil.

Degradation

Termiticide efficacy and persistence are primarily affected by the degradation rate of that compound. Once the termiticides are applied to soils, their fate relies on degradation processes. As the termiticide degrades, it is transformed into other compounds that may be more or less toxic than the parent insecticide. *Photodegradation:* The breakdown of chemicals due to exposure to sunlight is not a major factor because termiticides are usually applied below the soil surface. *Chemical degradation:* The most important process affecting termiticides is chemical degradation which involves *hydrolysis, oxidation* and *reduction*. This process directly affects the half life or residual of insecticides in soil.

Hydrolysis is a chemical process in which an insecticide reacts with water, resulting in splitting of the water molecules to form less toxic compounds. There is generally enough moisture in soil to initiate this reaction.

Oxidation is a chemical reaction through which an oxygen atom is added to the parent molecule of an insecticide. Initially, it may not appear that an oxidation reaction results in degradation of insecticides, but a more oxidized form of a molecule may be necessary for further microbial or chemical degradation.

Reduction is the third aspect of chemical degradation. An insecticide molecule is considered to be reduced if its hydrogen content increases or its oxygen content decreases. However, similar to oxidation, reduction may be a preliminary step toward further degradation by other processes. Reduction reactions generally occur under conditions where oxygen is limited (anaerobic environment). Reduction reactions may increase if a soil becomes flooded. As a result, termiticides applied to water-saturated soils may degrade rapidly, rendering the treatment unsuccessful. Areas with excessive water problems should always be corrected prior to termiticide application.

Volatilization

This process involves transforming chemicals from solid or liquid into a gas or vapor. Several factors influence the tendency of termiticides to volatilize and leave soil as a vapor. The structure of the chemical is important because this determines its vapor pressure as well as its solubility in soil water and its tendency to be adsorbed. Cool and dry conditions in soils with high organic matter or clay content normally result in very little loss of even the most volatile chemicals from the soil. Conversely, warm and moist conditions contribute to great desorption and greater volatilization losses.

Many processes influence efficacy, persistence and movement of termiticide in soil. Knowledge of these processes can ultimately lead to better understanding of behavior and performance of termiticide products in various soils.

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